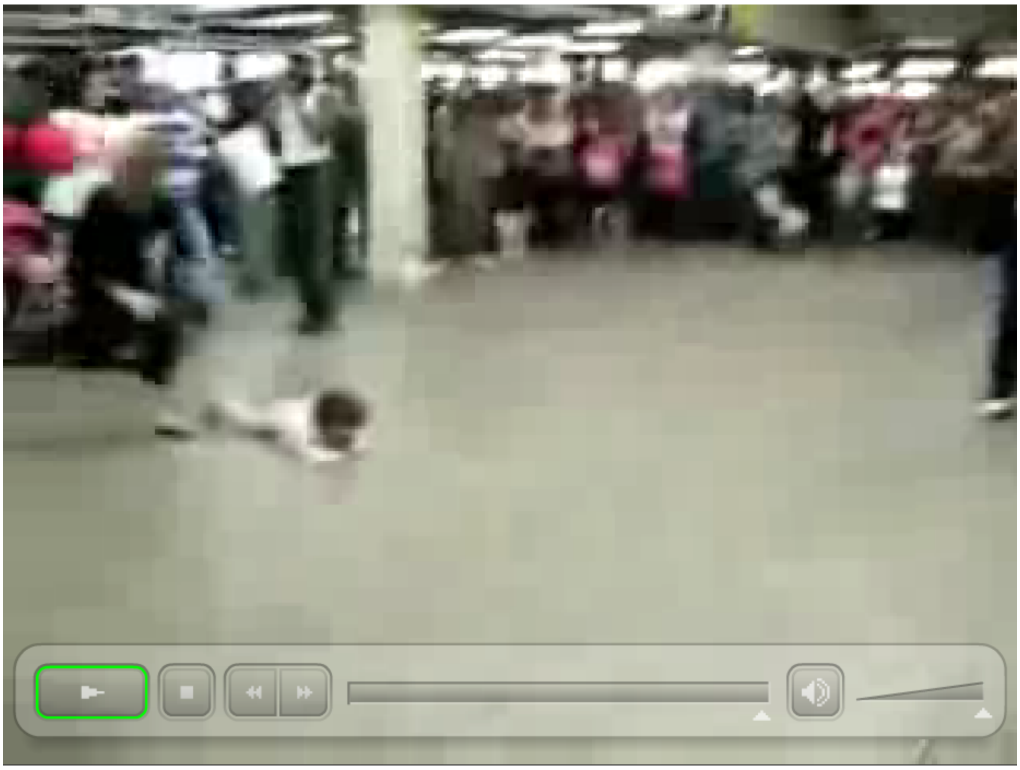
L06 - Collisions in 1-Dimension
- Elastic and Inelastic Collisions

https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html

.

Collisions in 1-Dimension (Office)

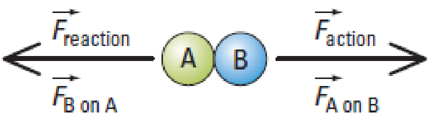


Conservation of Momentum in 1-Dimension

Why did cannons on 16th- to 19th-century warships need a rope around the back, tying them to the side of the ship (Figure 9.33)?

◀ **Figure 9.33**

Scroll Down

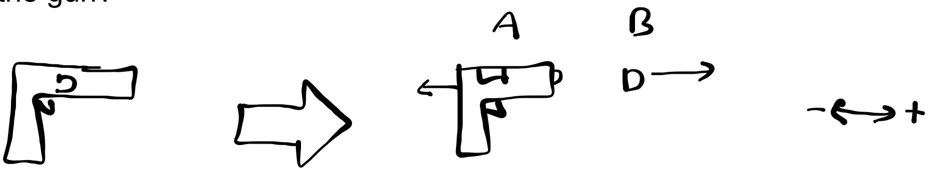


▲ **Figure 9.34**
The action-reaction forces when two objects collide

$$\vec{F}_{AonB} = -\vec{F}_{BonA}$$
$$\vec{F}_{AonB}\Delta t = -\vec{F}_{BonA}\Delta t$$
$$\Delta\vec{p}_B = -\Delta\vec{p}_A$$

Key Idea - Momentum is always conserved in isolated systems
(Momentum before = Momentum after).

Q1: An 0.050 kg bullet is fired from a 5.0 kg gun. If the velocity of the bullet is 275 m/s, what is the recoil velocity of the gun?



$$\vec{p}_{i_{sys}} = \vec{p}_{f_{sys}}$$

$$m_{sys}v_{sys} = \vec{p}_{f_A} + \vec{p}_{f_B}$$

$$(5.05\,kg)(0\,m/s) = (5\,kg)\vec{v}_{A_f} + (0.05)(+275\,m/s)$$

$$0 = 5\vec{v}_{A_f} + 13.75$$

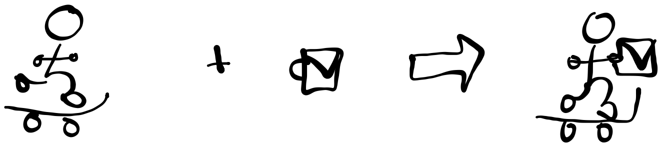
$$-13.75 \qquad\qquad -13.75$$

$$-13.75 = 5\vec{v}_{A_f}$$

$$\vec{v}_{A_f} = -2.75\,m/s\,[f]$$

Recoil backwards at 2.75 m/s

Q2: A student on a skateboard, with a combined mass of 78.2 kg, is moving east at 1.60 m/s. As he goes by, the student skillfully scoops his 6.4 kg backpack from the bench where he had left it. What will be the velocity of the student immediately after the pickup?



$$\vec{p}_{S_i} + \vec{p}_{B_i} = \vec{p}_{sys_f}$$

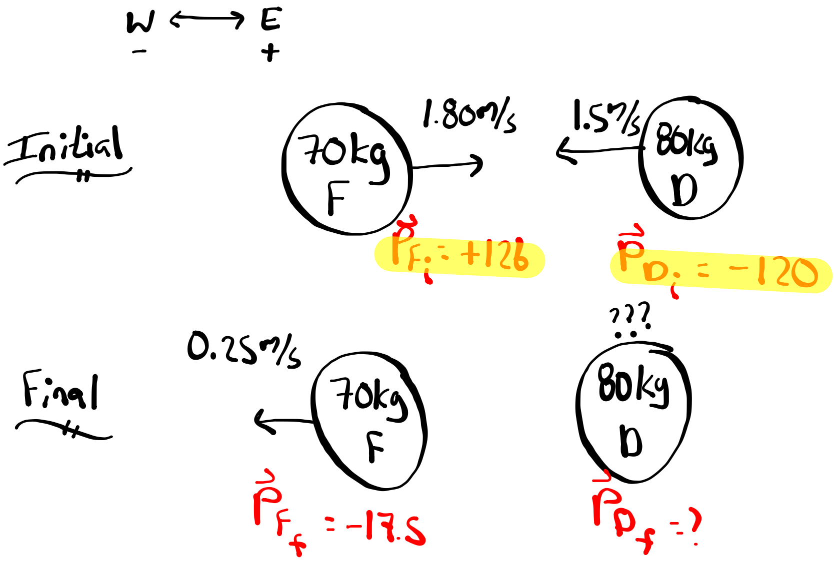
$$(78.2)(+1.6) + (6.4)(0) = (84.6)\vec{v}_{sys_f}$$

$$125.12 + 0 = 84.6\vec{v}_f$$

$$\vec{v}_f = +1.48\,m/s\,[f]$$

.

Q3: A 70 kg Wildcat football fullback moving east at 1.80 m/s on a snowy playing field is struck by a 80 kg Raiders defensive lineman moving west at 1.50 m/s. The fullback is bounced west at 0.250 m/s. What will be the velocity of the Raider defensive lineman just after impact?



$$\vec{P}_{i_{sys}} = \vec{P}_{f_{sys}}$$

$$+126 + (-120) = -17.5 + (80)\vec{v}_f$$

$$+6 = -17.5 + 80v_f$$

BEDMAS ←

$$+17.5 \quad\quad +17.5$$

$$23.5 = 80v_f$$

$$\vec{v}_f = +0.29375\ \text{m/s}\ [E]$$

.

Elastic and Inelastic Collisions in 1-Dimension

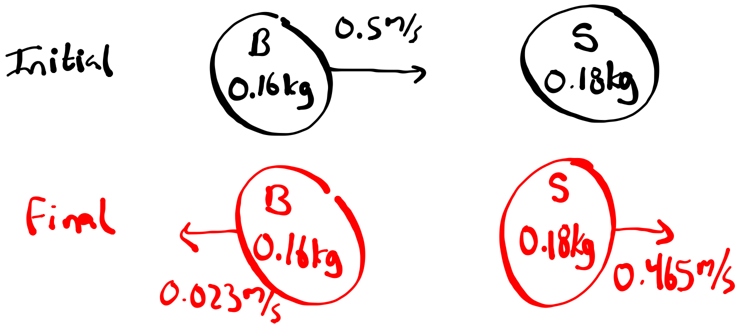
- Explain, qualitatively and quantitatively, that momentum is conserved in an isolated system.
- Define, Compare and Contrast elastic and inelastic collisions, using quantitative examples, in terms of conservation of kinetic energy.

Is this an Isolated System?

Q4: A 0.160 kg billiard ball travelling at 0.500 m/s [N] strikes a stationary 0.180 kg snooker ball and rebounds at 0.0230 m/s [S]. The snooker ball moves off at 0.465 m/s [N]. Determine if the collision is elastic.

Is E_k conserved?

S ← → N
− +



E_{k_i} vs E_{k_f} (Scalar → No direction → No negatives)

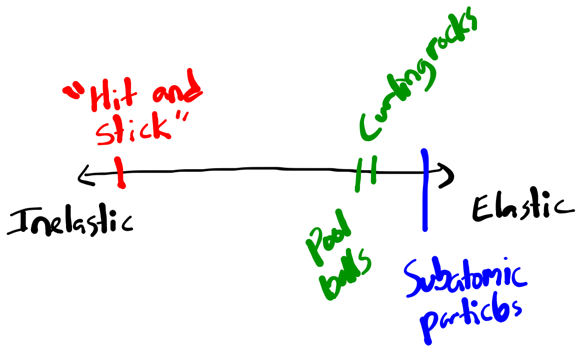
$E_{k_{i_B}} + E_{k_{i_S}}$ vs $E_{k_{f_B}} + E_{k_{f_S}}$

$\frac{1}{2}(0.16)(0.5)^2 + 0$ vs $\frac{1}{2}(0.16)(0.023)^2 + \frac{1}{2}(0.18)(0.465)^2$

$0.02 + 0$ vs $0.00004232 + 0.01946025$

$0.02\,J$ vs $0.0195\,J$

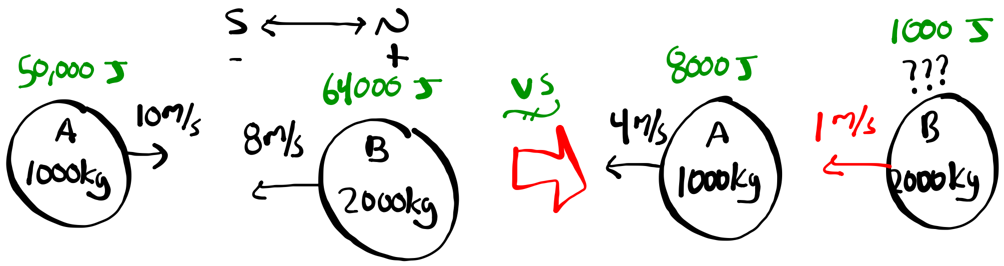
Pretty close to 100% elastic.



.

Q5: A compact car with a mass of 1.0 x 10^3 kg is moving at 1.0 x 10^1 m/s [N] along a single lane road. At the same time, a full size car with a mass of 2.0 x 10^3 kg is moving at 8.0 m/s south along the same road. The two cars collide head on. Immediately after the collision, the compact car has a velocity of 4.0 m/s [S]. The interaction lasted 8.0 x 10^{-2} s.

a) Deterime the speed and direction of the full size car immediately after the collision.
b) Show that the collision was not elastic.



$$\vec{P}_{A_i} + \vec{P}_{B_i} = \vec{P}_{A_f} + \vec{P}_{B_f}$$

$$(1000)(+10) + (2000)(-8) = (1000)(-4) + (2000)\vec{v}_f$$

$$10{,}000 + (-16{,}000) = (-4000) + 2000\vec{v}_f$$

$$-6000 = -4000 + 2000v_f$$

$$+4000 \qquad +4000$$

$$-2000 = 2000v_f$$

$$v_f = -1 \text{ m/s [N]}$$

$$= 1 \text{ m/s [S]}$$

Numeric Response and "Physics Principles"

Physics Principles

- 0 Uniform motion ($\vec{F}_{net} = 0$) - Chapter 1&2 No accel → $v = \frac{d}{t}$
- 1 Accelerated motion ($\vec{F}_{net} \neq 0$) - Chapter 1,2,3 Fnet → a → Kinematics Eqn
- 2 Uniform circular motion ($\vec{F}_{net}$ is radially inward) - Chapter 5
- 3 Work-energy theorem - Chapter 6 $W = \Delta E$
- 4 Conservation of momentum - Chapter 9 $\vec{p}_i = \vec{p}_f$
- 5 Conservation of energy - Chapter 6 $E_i \rightarrow E_f$
- 6 Conservation of mass-energy
- 7 Conservation of charge
- 8 Conservation of nucleons
- 9 Wave-particle duality

Physics Principles:

Isolated System: A group of objects assumed to be isolated from all other objects in the universe.

PP3: Work-Energy Theorem: Work done on a system is equal to the sum of the changes in the potential and kinetic energies of the system.

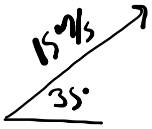
PP4: Law of Conservation of Momentum: Momentum of an isolated system is constant.

PP5: Law of Conservation of Energy: Within an isolated system, energy may be transferred from one object to another or transformed from one form to another, but it cannot be increased or decreased.

.

Numeric Response and "Physics Principles"

Q6: A golf ball is hit at 15 m/s [35°]. Two physics principles must be used to determine the magnitude of the horizontal displacement. Match the physics principles with the order in which they are used.



y-comp: v_i, $a = -9.81$, $d = 0$, $t = ?$ → Accel Mot.

x-comp: v_x, $d = ?$, t → Uniform Mot.

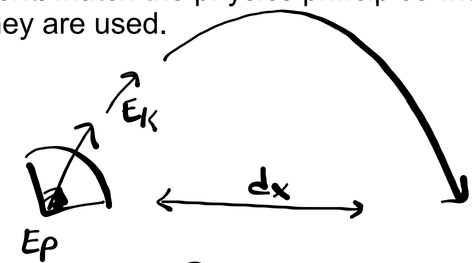
Number: 1 and 0

Physics Principle: Used First / Used Second

(Record all two digits of your answer in the numerical-response section on the answer sheet.)

1	0		

Q7: An archer is using a bow of spring constant 425 N/m, and pulls the arrow back 0.51m. He releases the arrow at an angle of inclination of 45°. Three physics principles must be used to determine the magnitude of the horizontal displacement. Match the physics principles with the order in which they are used.



5 (A) $E_p \to E_K$ solve for v

(B) y-comp

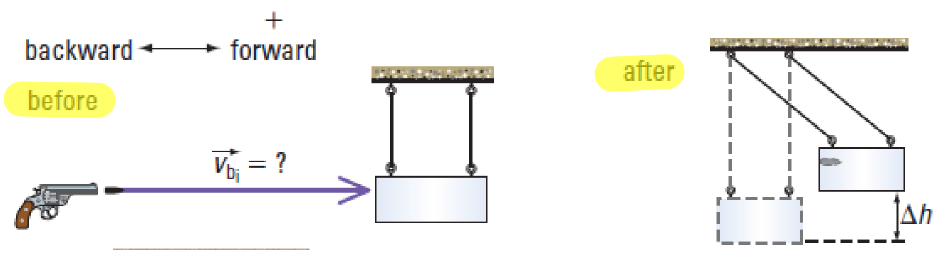
(C) x-comp

5	1	0	

Numeric Response and "Physics Principles"

Use the following information to answer Q8-Q9:

A 0.0149-kg bullet from a pistol strikes a 2.0000-kg ballistic pendulum. Upon impact, the pendulum swings forward and rises to a height of 0.219 m.



Collision
Cons of $\vec{p}$

Pendulum $E_K \rightarrow E_p$
Cons of E

Q8: A 0.0149-kg bullet from a pistol strikes a 2.0000-kg ballistic pendulum. Upon impact, the pendulum swings forward and rises to a height of 0.219 m. What as the velocity of the bullet immediately before impact?

$\vec{p}_{bullet_i} + \vec{p}_{block_i} = \vec{p}_{sys_f}$

$(0.0149)\vec{v}_i + 0 = (2.0149)(2.073)$

$0.0149 v_i = 4.1766208489$

$\vec{v}_i = 280.310126503\ m/s$

$\vec{v}_i \approx 280.3\ m/s\ [f]$

$E_K \rightarrow E_p$

$\frac{1}{2}mv^2 \rightarrow mgh$

$\frac{1}{2}(2.0149)v^2 = (2.0149)(9.81)(0.219)$

$1.00745v^2 = 4.328791011$

$\div 1.007\ldots \qquad \div 1.007\ldots$

$v^2 = 4.29678$

$v = 2.073\ m/s$

Q9: Two physics principles must be used to determine the magnitude of the bullet's velocity. Match the physics principles with the order in which they are used.

5	4		

.